Chapter 9
Energy Efficient Association Method for Wireless Sensor Networks

Jae-Hyung Lee
Kumoh National Institute of Technology, Korea

Dong-Sung Kim
Kumoh National Institute of Technology, Korea

ABSTRACT
This chapter describes an energy efficient association method for Wireless Sensor Networks (WSNs). The described method can be used to implement an association procedure by which an improved processing rate can be achieved by using a Beacon Only Period (BOP). The performance of mobile nodes is enhanced by using information on depth, traffic, and Received Signal Strength Indicator (RSSI). By using the Energy Efficient Association (EEA) method, trusted data can be transferred, and traffic overloads that occur at specific nodes can be prevented. In order to research the performance of the described method, the obtained information, such as depth, traffic rate, and RSSI from the relay nodes, is investigated and analyzed. Simulation results show that the EEA method can be used to obtain an efficient network configuration according to the mobility of nodes in WSNs.

INTRODUCTION
Recently, wireless communication has been studied as a very attractive option for industrial and factory automation, power plant systems, distributed control systems, and other kinds of networked embedded systems (Taslidere, 2011; Han, 2011; Dimokas, 2011). Wireless technologies that can be adopted to develop WSNs (Wireless Sensor Networks) and Fieldbus systems include Wi-Fi (IEEE 802.11-WLANs), Bluetooth, and technologies based on the IEEE 802.15.4 standard (IEEE Standard for Information Technology, 2007).
Wi-Fi and Bluetooth technologies have penetrated small office and home office as well as large enterprise office. However, these wireless technologies may find their limited usage in industrial installations due to harsh environments, interference problems, safety, security, and energy consumption for battery lifetime. To respond to the need for standard for industrial solutions, there are some working groups, i.e., the ZigBee Alliance, WirelessHART (HART communication foundation) Communication Foundation (HCF), and ISA 100 that has been defined as ISA 100.11a (ISA100.11a Working Group) that is an open standard for process control in industrial automation and related applications. These specifications are all based on the IEEE 802.15.4 standard or its PHY layer. Thus, this chapter focuses the IEEE 802.15.4 standard for satisfying the following criteria in harsh environment:

- Optimized load-balancing association method for maximum network lifetime;
- Support of human waking-speed mobility for some particular network nodes (sinks);
- Time critical association procedure for frequently joining and withdrawal by mobility.

In most cases, sensor nodes use batteries for energy supply. Batteries have a finite lifetime, although it is possible to prolong this lifetime by combining energy-harvesting system (Roundy, 2004). In recent years, the fundamental goal of a WSN is to produce information from raw local data obtained by individual sensor node by prolonging the lifetime of WSN as much as possible and prevent connectivity degradation by employing aggressive energy management techniques. For increasing battery lifetime, energy-efficiency can be considered as the single most important design goal for sensor network hardware, algorithms, protocols, and applications. In this research, we consider an energy efficient association method for adding new nodes or mobile nodes that are frequently associated by mobility in WSNs.

In the IEEE 802.15.4 standard, for every newly added node, a table comprising a list of neighbors at a distance of one hop from the node is created. Then, the association procedure is performed by the node with the lowest depth, we called DBA (Depth-Based Association) method, for which the RSSI (Received Signal Strength Indicator) is greater than the standard in neighboring table. For such a network configuration, the processing time required to create the neighboring table is high. Because only depth is considered in the procedure, inefficient configurations are produced by a beacon that lacks information on the network at the time when a node sends a request to join the network. As a result, the newly added node generates a packet in order to join the network through a node at which traffic is concentrated; therefore, the performance of the overall network may be degraded and only the energy of a specific node may be consumed. To increase sensor node’s battery life, the load-balancing association scheme is demanded on WSNs, when new nodes or mobile nodes join the network.

In this article, we discuss the EEA (Energy Efficient Association) method. This method can be adopted not only to achieve an efficient network configuration but also to solve problems associated with node mobility. The EEA method can be used to obtain network information on the neighbors in one superframe by utilizing the BOP (Beacon Only Period). The use of this method results in a decrease in the CCA (Clear Channel Assessment) waiting time, random delays that are generated by the CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) mechanism, and the processing time required to create the neighboring table. By defining the EEA metric for adding a new node, the method can be used efficiently to add a new node that sends a request to join the network. The association procedure is based on three kinds of information, as detailed below.